AUTOMOTIVE ULTRAHIGH-STRENGTH ELECTRICAL RESISTANCE WELDED STEEL TUBE HAVING EXCELLENT
DELAYED FRACTURE RESISTANCE
[TAI-OKUREHAKAITOKUSEI NO SUGURETA JIDOSHA YO CHO-KOKYODO DENBO KOKAN]

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TITLE   (54): AUTOMOTIVE ULTRAHIGH-STRENGTH ELECTRICAL RESISTANCE
                                  WELDED STEEL TUBE HAVING EXCELLENT DELAYED FRACTURE
                                  RESISTANCE

FOREIGN TITLE   [54A]: TAI-OKUREHAKAITOKUSEI NO SUGURETA JIDOSHA YO CHO-
                                  KOKYODO DENBO KOKAN

[What is claimed is]

1. An automotive ultrahigh-strength electrical resistance welded steel tube having excellent delayed fracture resistance, characterized in that it consists of, in terms of percent by mass, 0.20 to 0.30% C, 0.05 to 0.50% Si, 0.80 to 2.0% Mn, 0.020% or less P, 0.020% or less S, 0.01 to 0.10% Al, 0.05 to 1.0% Cu, 0.05 to 1.0% Cr, 0.01 to 0.10% Ti, and 0.0005 to 0.0050% B, with the balance being Fe and incidental impurities, and the tensile strength being 1620 N/mm^2 or more.

2. The automotive ultrahigh-strength electrical resistance welded steel tube having excellent delayed fracture resistance according to Claim 1, characterized in that it contains, in terms of percent by mass, at least one chemical component selected from the group consisting of 0.01 to 0.10% Nb, 0.01 to 0.10% V, 0.01 to 0.10% Zr, 0.05 to 1.0% Mo and 0.05 to 2.0% Ni.

3. A manufacturing method for an automotive ultrahigh-strength electrical resistance welded steel tube having excellent delayed fracture resistance, characterized in that an electrical resistance welded steel tube that has been tubulized from a hot rolled steel

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sheet having the chemical components of Claim 1 or 2 is subjected to an induction

quenching in which said electrical resistance welded steel tube is heated at a

temperature of Ac_3 critical point or more and 950 degrees Celsius or less and is then

cooled by water, and the tensile strength is 1620 N/mm^2 or more.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention] The present invention relates to technical fields of

an ultrahigh-strength electrical resistance welded steel tube having excellent delayed

fracture resistance and a tensile strength of 1620 N/mm^2 or more and, more specifically,

the present invention relates to a technical field of an ultrahigh-strength electrical

resistance welded steel tube which can be used for a purpose which requires lightness in

weight and high strength, such as reinforcing parts for automotive door impact beams and

bumpers.

[0002]

[Prior Art] In recent years, from the standpoint of the environmental preservation of the

Earth, there has been an increasing demand for improvement in fuel economy of automotives.

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For this reason, in order to reduce the weight of automotives, there has been an increasing demand for the use of reinforcing parts, such as door impact beams, of automotives having a high tensile strength. For example, Japanese Unexamined Patent Publication No. S57-134765 discloses a manufacturing method for a high-strength material having a hardness $Hv \geq 600$ wherein, prior to a quenching process of the resulting steel tube, a quenching process is conducted after a normalizing process in order to homogenize the quenching structure. Japanese Unexamined Patent Publication No. H1-261718 discloses a manufacturing method for a quenching steel tube having a tensile strength ≥ 120 kgf/mm^2 (1180 N/mm^2) or less.

[0003] However, it has been already well known that such ultrahigh-strength steel materials form hydrogen embrittlement cracks, i.e., delayed fracture, as described in Japanese Unexamined Patent Publication No. S60-155644 which discloses a bolt constituted of an ultrahigh-strength steel having a tensile strength of 980 N/mm^2 or more. Therefore, in various steel parts constituted of ultrahigh-strength steel tubes, hydrogen which can

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be generated by corrosion under an atmospheric environment invades such steel parts, resulting in delayed fracture suddenly occurring during use.

[0004] Further, in order to reduce the weight of the above-described reinforcing parts, many methods for achieving a high-strength steel tube have been proposed. For example, Japanese Unexamined Patent Publication No. H5-9579 discloses a method for manufacturing a steel tube having a tensile strength of 120 to 150 kgf/mm^2 (1180 to 1470 N/mm^2) by means of precipitation strengthening, and Japanese Unexamined Patent Publication No. H5-65541 discloses a method for manufacturing an ultrahigh-strength steel tube having a tensile strength of 150 to 190 kgf/mm^2 (1470 to 1860 N/mm^2) by specifying the components and manufacturing conditions.

[0005] On the other hand, as for delayed fractures, Japanese Unexamined Patent Publication No. H5-339678 discloses a method for manufacturing a steel tube having a tensile strength of 130 to 170 kgf/mm^2 (1270 to 1670 N/mm^2) by adjusting the main components, and the publication indicates that delayed fracture properties can deteriorate at a tensile strength exceeding 170 kgf/mm^2 (1670 N/mm^2). Further, Japanese Unexamined Patent Publication No. H7-126750 discloses a manufacturing method wherein a

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steel tube having the highest hardness Hv of 550 or less, including the welding areas, is

heat-treated at a temperature of 600 degrees Celsius or less, but the tensile strength of

the steel tube that can be obtained in the above publication is 1180 N/mm^2, which is lower

than the tensile strength the present invention is aiming at, 1620 N/mm^2 or more. Hence,

the reinforcing parts which have been ultrahigh-strengthened achieve the weight-reduction

but fail to improve the delayed fracture properties. In addition, in order to ensure good

delayed fracture properties, the resulting tensile strength can be low.

[0006] Further, as for the prevention of delayed fracture of an ultrahigh-strength thin

steel sheet, Japanese Unexamined Patent Publication No. H4-268053 discloses a method for

preventing the generation of hydrogen embrittlement, which is a cause of the delayed

fracture, by adding Si to the steel sheet in order to prevent the invasion of hydrogen

into the steel sheet. However, the cause of the delayed fracture is not always the

invasion of hydrogen; the stress concentration by the formation of corrosion pits can

also be a major cause. Therefore, it is difficult for the occurrence of the delayed

fracture to be adequately prevented by only the addition of Si.

[0007]

[Problems to be Solved by the Invention] It is obvious that the steel materials that constitute reinforcing parts for automotive door impact beams require a specific tensile strength, but such steel materials further require excellent toughness which adequately withstands shocks and excellent resistance against delayed fracture in association with high-strength steel materials.

[0008] The present invention was completed in order to solve the above-described problems and intends to provide an ultrahigh-strength automobile electrical resistance welded steel tube which is a quenching-type ultrahigh-strength electrical resistance welded steel tube having a tensile strength of 1620 N/mm^2 or more and has excellent delayed fracture resistance.

[0009]

[Means of Solving the Problems] The outline of the means of solving the above-described problems is an automotive ultrahigh-strength electrical resistance welded steel tube having excellent delayed fracture resistance, characterized in that it consists of, in terms of percent by mass, 0.20 to 0.30% C, 0.05 to 0.50% Si, 0.80 to 2.0% Mn, 0.020% or less P, 0.020% or less S, 0.01 to 0.10% Al, 0.05 to 1.0% Cu, 0.05 to 1.0% Cr, 0.01 to

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0.10% Ti, and 0.0005 to 0.0050% B, with the balance being Fe and incidental impurities, and the tensile strength is 1620 N/mm^2 or more.

[0010] The means of solving the above-described problems further includes an automotive ultrahigh-strength electrical resistance welded steel tube having excellent delayed fracture resistance, characterized in that it contains, in terms of percent by mass, at least one chemical component selected from the group consisting of 0.01 to 0.10% Nb, 0.01 to 0.10% V, 0.01 to 0.10% Zr, 0.05 to 1.0% Mo, and

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0.05 to 2.0% Ni.

[0011] The means of solving the above-described problems further includes a manufacturing method for an automotive ultrahigh-strength electrical resistance welded steel tube having excellent delayed fracture resistance, characterized in that an electrical resistance welded steel tube that has been tubulized from a hot rolled steel sheet having chemical components as described above is subjected to an induction quenching in which said electrical resistance welded steel tube is heated at a temperature of Ac$_3$ critical

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point or more and 950 degrees Celsius or less and is then cooled by water, and the

tensile strength is 1620 N/mm^2 or more.

[0012]

[Modes of Implementing the Invention] The present inventors conducted intensive research

on chemical components for the production of a steel material in order to satisfy these

three elements: tensile strength, toughness and delayed fracture resistance. As a result,

the present inventors discovered an ultrahigh-strength quenching steel tube that could be

preferably used as a reinforcing part, such as automotive door impact beams. More

specifically, the components in the steel was limited, considering the quenching

properties which improve the strength and toughness level of the quenching steel tube,

have delayed fracture resistance and correspond to an induction quenching. Hence, the

present inventors discovered that, an ultrahigh-strength steel tube having strength,

toughness and delayed fracture resistance, which are required for a reinforcing part,

such as an impact beam, could be manufactured at high productivity by an induction

quenching, which can be readily undertaken.

[0013] The delayed fracture of a high-strength steel is assumed to be caused by localizing diffusible hydrogen invaded into the steel at a portion by the tension gradient and causing the hydrogen embrittlement on the steel at that portion. Although various mechanism have been proposed with regard to the hydrogen embrittlement, such as surface pressure theory and cohesion reduction theory between iron atoms, the mechanism has not yet been completely revealed; however, it can be understood that these three factors including absorbability of hydrogen, diffusivity of hydrogen, and hydrogen embrittlement sensitivity of the steel itself, mutually interact with one another.

[0014] Hence, three countermeasures, from the steel material side, which are considered to be effective on the hydrogen embrittlement are: (1) to block the entry pathway of the hydrogen; (2) to inhibit the diffusion of hydrogen in the steel and the concentration of hydrogen at the tensile stress part; and (3) to reduce the hydrogen embrittlement sensitivity of the steel itself. The above items (2) and (3) have been often applied as countermeasures for the hydrogen embrittlement, but focus is placed on the item (1) in the present invention.

[0015] More specifically, the hydrogen absorption of a steel material under a normal usage environment is attributed to the fact that the hydrogen generated by a cathode reaction during corroding the steel material is not gasified but invades the steel material; therefore, the countermeasure (1) can be conducted according to the present invention by improving the corrosion resistance of the steel material and preventing the hydrogen absorption. Further, as another aspect that improves the corrosion resistance, according to the present invention, the stress concentration on the surface of the steel material can be prevented by inhibiting the ununiform corrosion; this countermeasure is equivalent to the above countermeasure (2). Further, the reduction of the hydrogen embrittlement sensitivity of the steel material itself described in the above countermeasure (3) can be responded to by reducing the content of the grain boundary segregation elements or refining the crystal grains.

[0016] In the present invention, intensive research was conducted on the components to be added in order to improve the strength, toughness and delayed fracture resistance of an ultrahigh-strength electrical resistance welded steel tube and, as a result, an ultrahigh-strength electrical resistance welded steel tube which had excellent toughness

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and delayed fracture resistance in spite of having a tensile strength of 1620 N/mm^2 or

more could be successfully obtained by using specific elements, which are described later.

[0017] The reasons for limiting the chemical components used in the inventive ultrahigh-

strength electrical resistance welded steel tube are as follows.

[0018] C: The present invention intends to strengthen a steel material by means of

quenching martensite, the strength of which can be determined by a content of C in the

steel material. For this reason, C is an essential element in order to produce a low-

temperature transformed structure, such as martensite, in the steel tube, thereby highly

strengthening the steel tube; in particular, in order to obtain a strength of 1620 N/mm^2

or more as in the case with the present invention, the C content must be at least 0.20%

as shown in Fig. 1. However, if the content exceeds 0.30%, the ductility and toughness

may deteriorate despite the fact that the strength can be improved. As a result, the

resulting steel tube may be damaged due to the brittleness when an impact load is applied

and therefore shows undesirable properties for the use as an impact beam. In addition,

the deterioration of the resistance of hydrogen embrittlement can be promoted due to the

deterioration of corrosion resistance; therefore, the upper limit of the C content is set to be 0.30%.

[0019] Si: Si is an element which can be used as a deoxidizing agent for a steel material and effectively improves the quenching properties. Si is a useful element which solid-solution strengthens the steel material without impairing the ductility and prevents the invasion of hydrogen caused by corrosion by means of densifying the produced rusts. Further, Si is a significantly useful element which maintains the soundness of the welded areas when a steel tube is manufactured by electric resistance welding. The Si content must be 0.05% or more in order to obtain the above-described effects. The upper limit of the content is set to be 0.50% in order to inhibit the production of oxides, which may be referred to as "penetrators", produced in electric resistance welding.

[0020] Mn: Mn is a useful element which reduces the martensite transformation temperature of a steel material, improves the quenching properties, and stably ensures high strength by preventing the occurrence of insufficient quenching strength, which can be caused by self-tempering after transformation in the course of quenching. The content must of Mn be 0.80% or more in order to obtain the above-described effects. However, if the content

exceeds 2.0%, the effect may not only be saturated but also increase the segregation, resulting in the structure being ununiform; therefore, the upper limit of the Mn content is set to be 2.0%.

[0021] P: P is a useful element which strengthens a steel material and improves the ductility, but may readily cause grain boundary segregation, resulting in the grain boundary strength being reduced and the toughness also being reduced; therefore, the P content is set to be 0.020% or less.

[0022] S: S forms a non-metallic inclusion together with Mn and the like, and becomes a source of corrosion generation, thereby reducing the delayed fracture resistance and inducing several impairments, such as the deterioration of the toughness and the soundness of welded parts; therefore, the S content is set to be 0.020% or less.

[0023] Al: Al is a useful element which can be used as a deoxidizing agent for a steel material. In order to obtain this effect, the Al content must be at least 0.01%.

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However, if the content exceeds 0.10%, the cleanliness level of the steel material may be impaired, resulting in surface defect; therefore, the upper limit of the Al content is set to be 0.10%.

[0024] Cu: Cu is a significantly useful element which significantly reduces the corrosion rate of a steel material under the atmospheric environment and improves the delayed fracture resistance. Further, since Cu is more noble than iron in terms of electrochemistry, the corrosion resistance of the steel material can be synergistically improved. In order to effectively obtain the above-described effects, as shown in Fig. 2, the Cu content must be at least 0.05%. However, by contrast, Cu may induce the embrittlement at hot rolling and the upper limit of the Cu content is therefore 1.0%. Further, in order to prevent the embrittlement of the steel material at hot rolling, the Cu can be preferably added together with Ni in an equal amount of Cu

[0025] Cr: Cr is a useful element which improves the quenching properties of a steel material and the required Cr content is 0.05% or more. However, if the content exceeds 1.0%, penetrators can be readily generated in electric resistance welding, resulting in

the toughness required for a high-strength steel tube being reduced; therefore, the upper limit of the Cr content is 1.0%.

[0026] Ti: Ti refines crystal grains and has an effect on crystal grain inhibition by forming microscopic carbides. Further, Ti works as a trap site for diffusible hydrogen, reduces the hydrogen embrittlement sensitivity of a steel material and has an effect on densifying the produced rusts, thereby improving the corrosion resistance. Further, in a steel material containing B, the denitrification effect of Ti allows B to effectively work in order to ensure the desired quenching properties. In order to obtain this effect, the Ti content must be at least 0.01%. However, an excessive Ti content roughens the carbides, resulting in the toughness of the steel being reduced; therefore, the upper limit of the Ti content is 0.10%.

[0027] B: The quenching properties of a steel material can be significantly improved by the addition of B. Further, the element also improves the toughness of the quenching structure. In order to obtain these effects, the B content must be at least 0.0005%. However, if the B content exceeds 0.0050%, a carbide-boride composite represented by $M_{23}(C,B)_6$ can be formed in the steel, thereby reducing the quenching properties, and a

desired strength may not be obtained; therefore, the upper limit of the B content is set to be 0.0050%.

[0028] In addition to the above-described chemical components, the inventive ultrahigh-strength electrical resistance welded steel tube can further contain one or more chemical components described below.

[0029] Nb, V and Zr: These elements have useful effects, such as forming a stable carbonitride as in the case with Ti, inhibiting the crystal grain growth at quenching and preventing the toughness from deteriorating. In order to obtain these effects, the content of these elements must be 0.01% or more. If the content exceeds 0.10%, the concentration of C may be reduced in the matrix due to the insufficient solubility of the carbide in the induction quenching, in which a steel material can be heated for a short period of time. As a result, a desired strength may not be obtained. Therefore, the upper limit of the content of each element is set to be 0.10%.

[0030] Mo: Mo is a useful element that improves the quenching properties of a steel; the addition of Mo provides a higher-strength steel without increasing the C content, which impairs the delayed fracture resistance. Further, in the case where the addition of Mo

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ensures a high strength, the C content can be reduced, thereby improving the delayed fracture resistance. In order to obtain these effects, the Mo content must be at least 0.05%. However, an excessive Mo content reduces the ductility of the steel, and the element Mo is an expensive element and therefore increases the production cost. Therefore, the upper limit of the Mo content is set to be 1.0%.

[0031] Ni: Ni is a significantly useful element which improves the quenching properties of a steel material and increases the bond energy of iron atoms, thereby ensuring a high strength while inhibiting the deterioration of the toughness of the steel material. Further, Ni has an effect on improving the corrosion resistance of the steel material by densifying the produced rusts. In order to obtain these effects, the Ni content must be at least 0.05%, and is preferably 0.10% or more. However, an excessive Ni content not only impairs the property improving effect but also induces an increase in the cost of steel materials. Therefore, the upper limit of the Ni content is set to be 2.0%.

[0032] Next, the manufacturing method is described. According to the present invention, first, a steel bloom (slab) having chemical components as described above is subjected to a hot rolling in a conventional manner at a heating temperature of 1100 degrees Celsius

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or more and a coiling temperature of 650 degrees Celsius or less. In heating the steel

bloom, since the rolling load at hot rolling for a high-strength steel according to the

present invention tends to become high, the rolling temperature should not fall too low,

and the heating temperature for the steel bloom is therefore set to be 1100 degrees

Celsius or more. In this case, the heating method is not particularly restricted; known

examples of applicable methods include direct rolling method wherein a steel bloom which

has been continuously casted is directly rolled, mild heating method, and a method

wherein a steel bloom which has been once cooled is re-heated. However, if the heating

temperature exceeds 1300 degrees Celsius, heat energy may be consumed unnecessarily and

there may not be any particular benefits.

[0033] The hot rolling of the steel bloom can be conducted in a conventional manner, with

the finish rolling being conducted in an austenite single phase region at a temperature

of Ac_3 critical point or higher. The coiling can be preferably conducted at a temperature

of 650 degrees Celsius or less from the standpoint of removability of the scales from the

surface of the rolled steel sheet. However, if the coiling temperature is too low, low-

temperature transformation structures of bainite and martensite may be mixed and the

strength may become high, resulting in the tubulization being difficult; therefore, the

lower limit of the coiling temperature is set to be 450 degrees Celsius. The hot-rolled

steel sheet thus obtained has a strength of 390 N/mm^2 to 690 N/mm^2, which is a standard

strength level of conventional electrical resistance welded tubes, and can therefore be

subjected to tubulization under the same conditions as conventional hot-rolled steel

sheets.

[0034] The hot-rolled steel sheet (sheet belt) thus obtained is washed with acids,

grinded and is subjected to a treatment, such as shot blasting, in order to remove scales

on the surface in a conventional manner, and the resulting hot-rolled steel belt is slit

up at a predetermined width in a conventional manner, thereby forming an electrical

resistance welded tube. The welding in tubulization applied was a conventional high

frequency induction welding.

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[0035] The cross section of the resulting electrical resistance welded tube is preferably

the original circular cross section from the standpoint of the production cost and

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workability of the heat-treatment, but can also be formed into a rectangular steel tube

having a rectangular cross section depending on the intended use.

[0036] The heat treatment in which a predetermined strength is provided with the

resulting electrical resistance welded tube is an induction quenching in which portions

which have been heated for a short period of time are serially cooled with water and then

quenched. The induction quenching is preferred because the deformation after heat

treatment can be prevented and an electrical resistance welded tube having excellent

characteristics of the actual core shape can be obtained.

[0037] In the induction quenching, the electrical resistance welded tube is heated at a

temperature of Ac_3 critical point or more and 950 degrees Celsius or less and then cooled

to ambient temperature. If the heating temperature is lower than Ac_3 critical point and in

the dual phase between the critical points Ac_1 to Ac_3, the austenite which is present in

the temperature range is transformed into martensite and is hardened while ferrite is not

hardened, resulting in the quenching structure being a mixed structure having hard

martensite and soft ferrite; therefore, not only can the original objectives of quenching

not be achieved but also the desired strength cannot be obtained. If the heating

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temperature exceeds 950 degrees Celsius, austenite may be roughened during heating, resulting in the impact properties of the resulting quenched material being impaired. Further, if the heating temperature is too high, the quenching strength may be reduced. Therefore, the heating temperature range in quenching is set to be Ac_3 critical point or more and 950 degrees Celsius or less.

[0038] Any quenching structures can be used as long as they have a tensile strength of 1620 N/mm^2 or more. However, since it is difficult to precisely control the cooling rate after quenching in the induction quenching, for example, with a structure having a large content of bainite, the mechanical properties of the resulting electrical resistance welded tube may significantly vary; therefore, it is effective to mainly use a martensite structure of which the tensile strength does not depend on the cooling rate, from the standpoint of ensuring stable mechanical properties. For this reason as well, the C content is limited to be 0.20 to 0.30% so that the quenched structure become a martensite structure.

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[0039] In addition, tempering can be conducted after quenching in order to adjust the mechanical properties. However, since the heating treatment process may become complicated, it is slightly disadvantageous from the standpoint of the production cost.

[0040]

[Embodiments] Steel blooms having chemical components shown in Table 1 were heated at a temperature of 1200 degrees Celsius and were then rolled into a thickness of 2.0 mm under the rolling conditions shown in Table 2. From the resulting hot-rolled steel sheets, electrical resistance welded tubes having an external diameter of 31.8 mm and a thickness of 2.0 mm were manufactured and subjected to an induction quenching in which all the resulting steel tubes were cooled with water from a temperature of 900 ± 20 degrees Celsius. Samples were collected from the resulting quenched electrical resistance welded tube in order to investigate their tensile strength, impact properties and delayed fracture resistance. The results are shown in Table 2.

[0041] JIS #11 test pieces were used in the tensile test. The impact test was conducted according to JIS #4 impact test pieces, wherein a 2 mm V-notch test piece which had been obtained by cutting out a piece in the steel tube axial direction and processing it was

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used and subjected to the impact test consecutively three times at a temperature of -40 degrees Celsius. The value of impact properties shown in Table 2 is the average value from the three consecutive tests. The delayed fracture resistance was conducted by cutting out a tubular test piece having a length of 300 mm from a quenched electrical resistance welded tube, immersing the resulting test piece in an aqueous hydrochloric acid solution having a concentration of 1000 mol/m^3 for 300 hours, and visually observing hydrogen embrittlement cracks after immersion. The evaluation was conducted according to the presence of hydrogen embrittlement cracks, with the case with cracks being "o" and the case without cracks being "×" in Table 2.

[0042]

[Table 1]

No.	Chemical components (% by mass)												Note
	C	Si	Mn	P	S	Cu	Al	Ni	Cr	Ti	B	Others	
Steel 1	0.20	0.20	1.20	0.014	0.004	0.05	0.040	0.01	0.30	0.034	0.0030		Embodiment
Steel 2	0.24	0.21	1.30	0.012	0.007	0.13	0.038	0.01	0.35	0.025	0.0026		Embodiment
Steel 3	0.26	0.20	1.27	0.015	0.005	0.30	0.042	0.22	0.28	0.030	0.0028		Embodiment
Steel 4	0.30	0.22	1.35	0.011	0.003	0.50	0.035	0.90	0.32	0.038	0.0040		Embodiment
Steel 5	0.22	0.21	1.32	0.014	0.011	0.05	0.050	0.02	0.20	0.040	0.0029		Embodiment
Steel 6	0.23	0.22	1.80	0.014	0.012	0.45	0.040	0.40	0.18	0.034	0.0033		Embodiment
Steel 7	0.24	0.20	1.40	0.014	0.010	0.11	0.035	0.30	0.30	0.029	0.0032		Embodiment
Steel 8	0.28	0.20	1.30	0.014	0.004	0.92	0.038	1.50	0.32	0.033	0.0035		Embodiment
Steel 9	0.24	0.40	1.25	0.014	0.005	0.12	0.040	0.05	0.90	0.080	0.0050		Embodiment
Steel 10	0.28	0.35	1.28	0.014	0.007	0.10	0.042	0.10	0.30	0.034	0.0030	Nb: 0.04	Embodiment
Steel 11	0.22	0.20	1.30	0.014	0.006	0.10	0.040	0.05	0.33	0.034	0.0033	V: 0.07	Embodiment
Steel 12	0.26	0.21	1.27	0.014	0004	0.09	0.041	0.05	0.40	0.034	0.0025	Zr: 0.50	Embodiment
Steel 13	0.30	0.18	1.40	0.014	0.003	0.05	0.038	0.05	0.30	0.034	0.0029	Mo: 0.50	Embodiment
Steel 14	0.24	0.20	1.42	0.014	0.004	0.10	0.035	0.05	0.02	0.005	0.0030		Comparative Example
Steel 15	0.24	0.22	1.50	0014	0.005	0.02	0.033	0.05	0.30	0.005	0.0030		Comparative Example
Steel 16	0.34	0.24	1.50	0.014	0.007	0.01	0.040	0.02	0.33	0.034	0.0033		Comparative Example
Steel 17	0.24	0.19	0.75	0.014	0.002	0.02	0.032	0.01	0.28	0.034	0.0002		Comparative Example
Steel 18	0.16	0.20	1.30	0.014	0.010	0.01	0030	0.01	0.40	0.033	0.0030		Comparative Example
Steel 19	0.18	0.19	1.30	0.022	0.025	0.02	0.031	0.01	0.35	0.028	0.0035		Comparative Example
Steel 20	0.24	0.23	1.30	0.022	0.025	0.02	0.038	0.01	0.28	0.037	0.0037		Comparative Example

[0043]

[Table 2]

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No.	Rolling finish temperature (°C)	Coiling temperature (°C)	Yield temperature (N/mm²)	Tensile strength (N/mm²)	Elongation (%)	Impact properties vE -40 (J)	Delayed fracture resistance	Note
Steel 1	880	580	1203	1625	12.5	14.1	○	Embodiment
Steel 2	880	580	1361	1791	11.3	13.4	○	Embodiment
Steel 3	880	580	1369	1850	11.0	12.7	○	Embodiment
Steel 4	880	580	1631	2039	10.1	10.8	○	Embodiment
Steel 5	880	560	1267	1713	11.9	13.2	○	Embodiment
Steel 6	880	560	1369	1801	11.3	12.7	○	Embodiment
Steel 7	880	560	1314	1800	11.3	13.0	○	Embodiment
Steel 8	880	560	1465	1980	10.3	11.8	○	Embodiment
Steel 9	880	560	1346	1795	11.3	11.3	○	Embodiment
Steel 10	900	580	1447	1956	10.4	10.7	○	Embodiment
Steel 11	900	580	1265	1710	11.9	12.2.	○	Embodiment
Steel 12	880	580	1396	1887	10.8	11.5	○	Embodiment
Steel 13	880	580	1561	2129	9.5	10.2	○	Embodiment
Steel 14	880	580	1163	1615	12.6	9.6	×	Comparative Example
Steel 15	880	580	1340	1811	11.2	8.5	×	Comparative Example
Steel 16	880	580	1747	2212	8.2	5.6	×	Comparative Example
Steel 17	880	580	1173	1585	12.8	8.7	×	Comparative Example
Steel 18	880	580	1080	1460	13.9	12.7	×	Comparative Example
Steel 19	880	580	1154	1559	13.0	11.3	×	Comparative Example
Steel 20	880	580	1326	1792	11.3	11.6	×	Comparative Example

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[0044] As shown in Table 2, the examples according to the present invention, which have chemical components and induction quenching conditions within the range specified by the present invention, have excellent properties. By contrast, comparative example steel No. 14 has an insufficient content of Ti, which is a trap site for hydrogen, the steel No. 15 has an insufficient content of Cu, which improves the delayed fracture resistance, as well as an insufficient content of Ti, the steels No. 16 to 18 have an insufficient content of Cu, and the steels 19 and 20 have poor delayed fracture resistance because the steels have an excessive content of S, which impairs the delayed fracture resistance, and an insufficient content of Cu.

[0045] The comparative example steel No. 14 has insufficient contents of Cr and Ti, which are required for ensuring the quenching strength, and could not achieve the desired tensile strength, which is 1620 N/mm^2 or more. The steel No. 15, which has an insufficient Ti content but contains Cr, which is useful for ensuring a strength, has the desired tensile strength, but has poor delayed fracture resistance and low impact properties. The steel No. 17 has insufficient contents of Mn and B, which improve the quenching properties, and the steels 18 and 19 have an insufficient content of C; therefore, these steels could not achieve the desired

tensile strength, which is 1620 N/mm^2 or more. The steel No.
16, which has an excessive content of C, achieved a tensile
strength of 1620 N/mm^2 or more, but has poor ductility
(elongation) and impact properties.

[0046]

[Effect of the Invention] As is clear from the above
description, since the present invention includes an
induction quenching wherein chemical components which ensure
an adequate tensile strength and improve delayed fracture
resistance, an ultrahigh-strength automobile electrical
resistance welded steel tube having a tensile strength of
1620 N/mm^2 or more and excellent delayed fracture resistance
can be obtained.

[Brief Description of the Drawings]

[Fig. 1] Graph illustrating the relationship between the C
content in the steel after induction quenching and the
tensile strength.

[Fig. 2] Graph illustrating the relationship between the
immersion time until the occurrence of hydrogen
embrittlement cracks after immersion in an aqueous
hydrochloric acid solution having a concentration of 1000
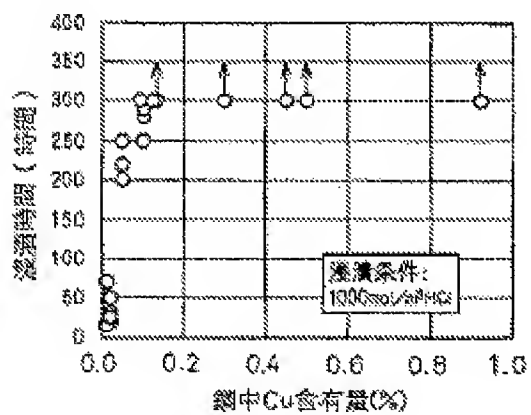mol/m^3 and the C content in the steel.

[Fig. 1]

1
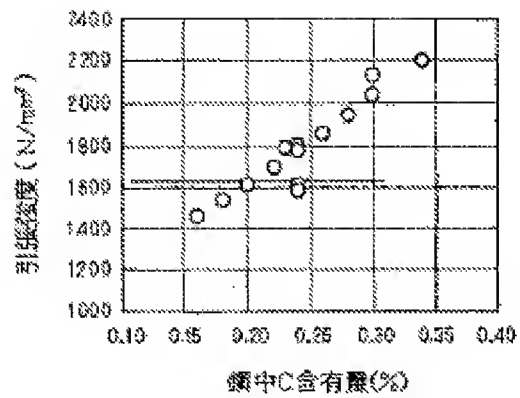
Abscissa: C content in the steel (%)

Ordinate: Tensile strength (N/mm^2)

[Fig. 2]

Abscissa: C content in the steel (%)

Ordinate: Immersion time (hour)

[Immersing condition: 1000 mol/m^3 HCl]